Seismic Analysis of R.C.C. Building With Plan Irregularities

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Abstract- *Earthquake never kills people but the defective structures do. The stability and stiffness of any structure is the major issue of concern in any high rise buildings. Shear walls are structural members which resist lateral forces predominant on moment resisting frame.*

***Keywords*-** Displacement, Story shear, SFD, BMD, Seismic etc.

I. INTRODUCTION

Amongst the natural hazards, earthquakes have the potential for causing the greatest damages. Since earthquake forces are random in nature & unpredictable, the engineering tools needs to be sharpened for analysing structures under the action of these forces. About 60% of the land area of our country is susceptible to damaging levels of seismic hazard. In future, earthquakes can't be avoided, but preparedness and safe building construction practices can certainly reduce the extent of damage and loss. The behaviour of a building during earthquakes depends critically on its overall shape, size and geometry, in addition to how the earthquake forces are carried to the ground. The earthquake forces developed at different floor levels in a building need to be brought down along the height to the ground by the shortest path; any deviation or discontinuity in this load transfer path results in poor performance of the building.
Although there are so many studies about earthquakes but however it has not been possible to predict when and where earthquake will happen. It has been learned how to pinpoint the locations of earthquakes, how to accurately measure their sizes, and how to build flexible structures that can withstand the strong shaking produced by earthquakes and protect our loved ones.

In recent times, damaging earthquakes experienced in our country include (1) Bihar Nepal earthquake (1988), (2) Uttarkashi earthquake (1991), (3) Killari earthquake (1993), (4) Jabalpur earthquake (1997), (5) Chamoli earthquake (1999) and (6) Bhuj earthquake (2001) and recently occurred (7) West Bengal earthquake (2011). In all of these earthquakes there is huge loss of life and very large destruction of existing reinforced concrete (RC) buildings. Most recent constructions in the urban areas consist of poorly designed and constructed buildings. The older buildings, even if constructed in compliance with prevailing standards, may not comply with the more stringent specifications of the latest standards of IS 1893(Part 1):2016, IS 4326:1993 and IS 13920: 1993.

1.1 Regular and Irregular structures

Buildings with simple regular geometry and uniformly distributed mass and stiffness in plan and in elevation, suffer much less damage, than buildings with irregular configurations. All efforts shall be made to eliminate irregularities by modifying architectural planning and structural configurations. A building shall be considered to be irregular for the purposes of this standard, even if any one of the conditions given in Tables 5 and 6 is applicable. Limits on irregularities for Seismic Zones III, IV and V and special requirements are laid out in Tables 5 and 6.

There are basically two types of irregularities in building,
1. Plan irregularity
2. Vertical irregularity

There are again various types plan irregularities such as,
a) Torsional Irregularity
b) Re-entrant Corners
c) Floor slabs having excessive cut-off and opening
d) Out-of-plane Offsets in vertical elements
e) Nonparallel lateral force system

II. LITERATURE REVIEW

Paper [1] shows Reinforced Concrete (RC) building frames are most common types of constructions in urban India. These are subjected to several types of forces during their lifetime, such as static forces due to dead and live loads and dynamic forces due to earthquake. This paper presents a review of the previous work done on multistoried buildings vis-à-vis earthquake analysis. It focuses on static and dynamic analysis of buildings[12].

In paper [2] the behaviour of G+11 multi-story building of regular and irregular configuration under earth quake is complex and it varies of wind loads are assumed to act simultaneously with earth quake loads. In this paper a residential of G+11 multistory building is studied for earth quake and wind load using ETABS and STAAS PRO V8i .Assuming that material property is linear static and dynamic analysis are performed. These analysis are carried out by considering different seismic zones and for each zone the behaviour is assessed by taking three different types of soils namely Hard , Medium and Soft .Different response like story drift, displacements base shear are plotted for different zones and different types of soils[13].

Paper [3] deals with the comparison between equivalent static technique &response spectrum technique. The earthquake effect lead to the damage the property and many people loss of life. So we have to know the structural performance under seismic load before construction. [7] Method of analysis Adopt the equivalent static and response spectrum techniques to analyze the model for the present study and observe the lateral displacement of the structure in a regular and irregular structure in various zones[11].

Paper [4] shows, It's a very big challenge that building or structure must withstand lateral forces such as earthquake and wind load. In the present work, the comparative analysis of various structures is performed using SAP 2000. [8] The main aim of the project is comparative study of the stiffness of the structure by considering the three models that is Regular Structure, Plan irregular structure and Vertical irregular structure. All these three models are analyzed with static and dynamic earthquake loading for the Zones II, III, IV & V. The results are tabulated and graphs are plotted for displacement, drift, base shear and time period. Based on the results and discussion the structural behavior and stiffness is concluded for regular and irregular structures, among these structures regular structure shown maximum displacement and drift for all the zones in both static and dynamic analysis[9].

In this paper [5] The national building code of India (NBC) 2015 was released by bureau of Indian standards during December 2016/january2017. The various sections of this NBC have undergone changes as per latest technologies and user requirements. It is necessary to identify the performance of the structures to withstand against disaster for both new and existing one. The paper discusses the performance evaluation of RC (Reinforced Concrete) Buildings with plan irregularity. Structural irregularities are important factors which decrease the seismic performance of the structures [6]. This study as a whole makes an effort to evaluate the effect of plan irregularity on RC buildings using IS 1893:2002 and IS 1893:2016 in terms of dynamic characteristics[10].

[11] This project is concerned with the study of seismic analysis and design of high-rise building. The structural analysis of high rise multistory storey reinforced concrete symmetrical and asymmetrical frame building is done with the help of SAP software. In the present study, The Response spectrum analysis (RSA) of regular RC building frames is compare with Response spectrum analysis of regular building and carry out the ductility-based design. as per IS 1893:2002 and IS 1893:2016.

[12] Many changes and improvement in the Earthquake resistant design of structure is done in past recent years. It results in the changes in the Indian seismic code IS 1893 which is revised and drafted in year 2016, after a time elapsed of nearly 14 years. In this paper we represent the seismic load assessment for multistory building as per IS: 1893-2002 and IS: 1893-2016 recommendations. Considering and analyzing the four storey RC framed multi-storey building. It is concluded that such study is done on individual RC framed building structure which is designed using earlier code. To predict the seismic vulnerability of building structure and to check due to revisions and changes in the IS codal provisions the structure is safe or unsafe.[13] As the analysis of the building structure is carried out from both IS codes to inspect the changes done in latest IS code for calculating lateral force of the multi-storey building. The strong and ductile structure is designed as per seismic design approach of both IS codes. The lateral forces acting on the upper storey are more than the lower storey of the building. As we increase the no. of storey in the building the lateral forces acting on the upper storey of the building increases with increase in the base shear of the building. The lateral load and seismic force calculated is same. The building is safe as per revised code and no any structural deficiency is found. There is no need retrofitting of building to withstand expected design earthquake vibration.

[14] The foundation of a building is the substructure through which the loads of the whole structure are transmitted to the soil. There are various types of soil present in India. The types of soil play a major role while designing a structure. Here the analysis and design of building is done by varying the type of soil. The difference in analysis of structure is studied. After that the seismic analysis for various zones are carried out for the same soil conditions and also by changing the model of building, the same are done. And the difference is studied

1. From model analysis the time period obtained from all zones are same and its same for all soil conditions as in table.
2. By static earthquake analysis the base shear obtained is maximum for fixed support conditions and for hard soil conditions then the base shear is decreasing to medium soil and then to soft soil. When comparing the zones in static earthquake analysis zone I have lowest base shear then its increases by zone II, zone III and zone IV as shown in table.
3. But in case of story displacement Zone I have lowest displacement. Then Zone II have comparatively 7-8 % increase than zone I. when going to zone III and zone IV an average of 7-8% increase in story displacement by Time History analysis (Elcentro) the base shear and story displacement obtained during analysis is comparatively lesser than Static earthquake analysis. Due to this the steel required is comparatively lesser than static earthquake analysis[15].

III. OBJECTIVE OF THE PROJECT

The objective of the present study is to analyze R.C.C. buildings of plan irregularities using response spectrum analysis method. The different objectives of the present study are:

1. The present study is an effort to understand response spectrum analysis method.
2. To employ STAAD PRO software.
3. To study parameters such as base shear, displacement, peak story and story drift.
4. To study seismic response of building with plan discontinuities under earthquake excitations.

IV. METHODOLOGY

Investigations of past and recent earthquake damage have illustrated that the building structures are vulnerable to severe damage or collapse during moderate to strong ground motion caused by earthquake. An earthquake with a magnitude of six is capable of causing severe damages of engineered buildings, bridges, industrial and port facilities as well as give rise to great economic losses. Several destructive earthquakes in India shows that the RC buildings are mostly damaged and some of them are collapsed. The main reason behind this is non-consideration of earthquake forces while designing, constant upgradation of codes, false supervisions, faulty construction practices adopted and many more.

Earthquake loads are to be carefully modeled so as to assess the real behavior of structure with a clear understanding that damage is expected but it should be regulated. In this context response spectrum analysis is carries out which is a dynamic analysis procedure shall be looked upon as an alternative for the orthodox analysis procedures. This study focuses on analysis of regular and irregular building in different seismic zones, the regular building and different plan irregular building are considered in II, III, IV, V seismic zones and are analysis to evaluated different parameters.

4.1 Computational Analysis

In this Linear static analysis and linear dynamic analysis are performed on the buildings taken under consideration as mentioned above by using STAAD PRO software. Computational models of all buildings are shown in Figure 4.4.1- Figure 4.4.4.

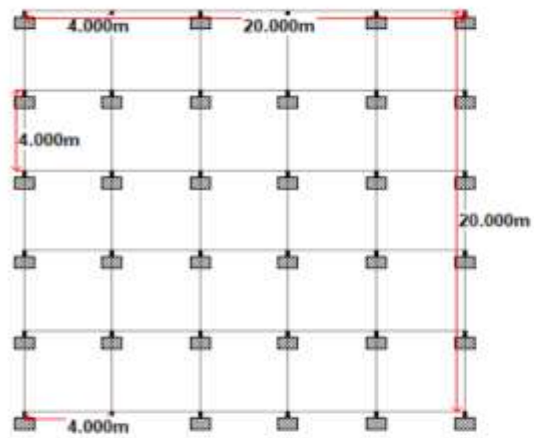

Fig4.1 Regular building plan

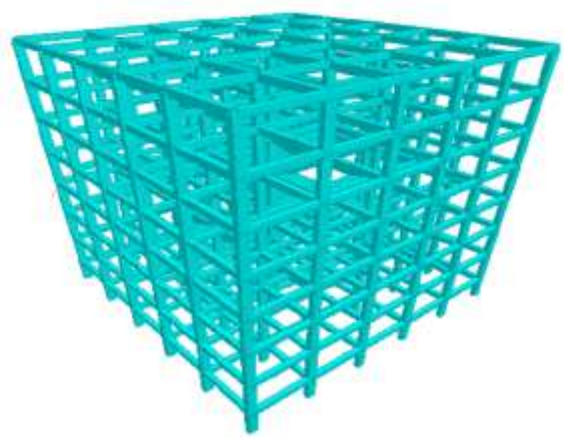

Fig 4.2 Regular building 3D model

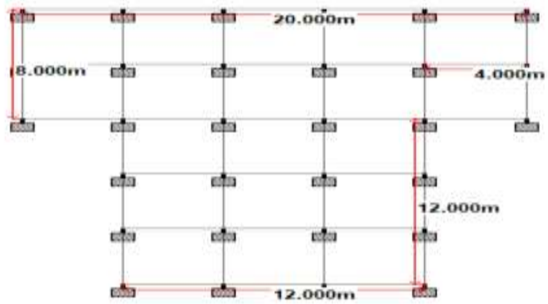

Fig: 4.3 T- Shape Plan

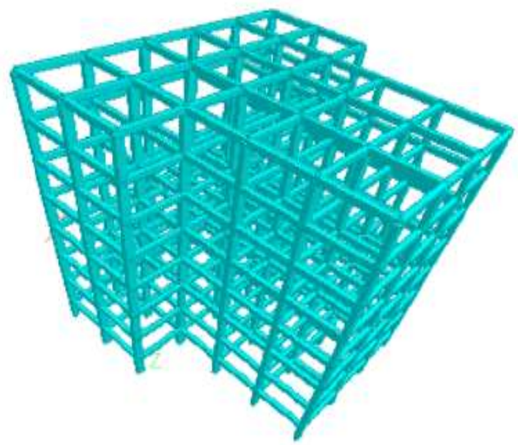

Fig: 4.4 T- Shape 3D Model

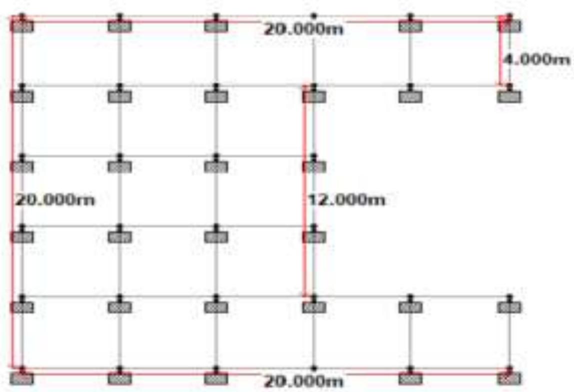

Fig: 4.5 C-Shape Plan

V.RESULTS

A G+6 regular and irregular T shape and C shape buildings are model in zone II, III, IV, V using STADD PRO software and the results are computed. Twelve models were prepared in different zones, these models are analyzed as per the specifications of Indian Standard codes IS1893 – 2016, IS 875 and IS 456: 2000. The equivalent static method and response spectrum method have been used to find the nodal displacement in the storey for X, Y and Z direction of the regular and irregular building, peak storey shear, base shear and max BM and SF

1. Nodal Displacement in the Storey for X, Y and Z Direction of the Regular and Irregular Building

Elements or members of building should be designed and constructed to resist the effects of design lateral force. STAAD Pro gives the lateral force distribution at various levels and at each storey level. Lateral force of earthquake is predominant force which needs to be resisted for any structure to be earthquake resistant. The equivalent static method and response spectrum method have been used to find the nodal displacement in the storey for X, Y and Z direction of the regular and

Table 5.1 Displacement in different zones along X-direction by equivalent static method.

Building	**zone 2**	**zone 3**	**zone 4**	**zone 5**
Max displacement	**x**	**x**	**x**	**x**
Static				
Regular	40.547	64.804	97.148	145.663
T Shape	40.505	64.766	97.114	145.637
C shape	38.714	62.05	93.164	139.836

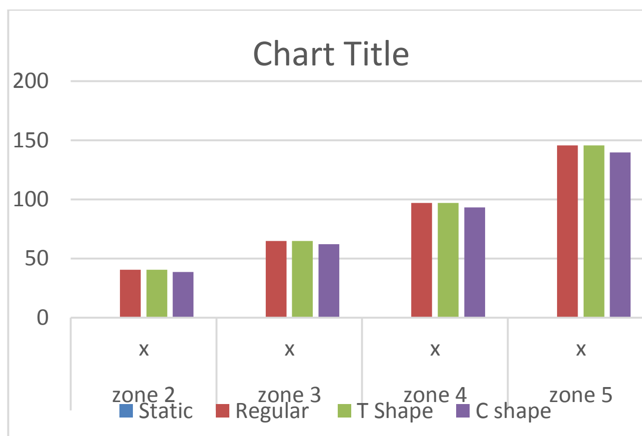

Fig 5.1: - Displacement in different zones along X-direction by equivalent static method.

As per the above table and graph zone is ascending lateral displacement increasing and C shape irregular building has lesser displacement than regular shape and T shape in X direction.

Table 5.2 Displacement in different zones along Z-direction by Equivalent static method.

Building	**zone 2**	**zone 3**	**zone 4**	**zone 5**

Max displacement	**Z**	**Z**	**Z**	**Z**
Static				
Regular	62.751	100.35	150.482	225.681
T Shape	60.49	96.983	145.641	218.627
C shape	61.905	99.098	148.689	223.077

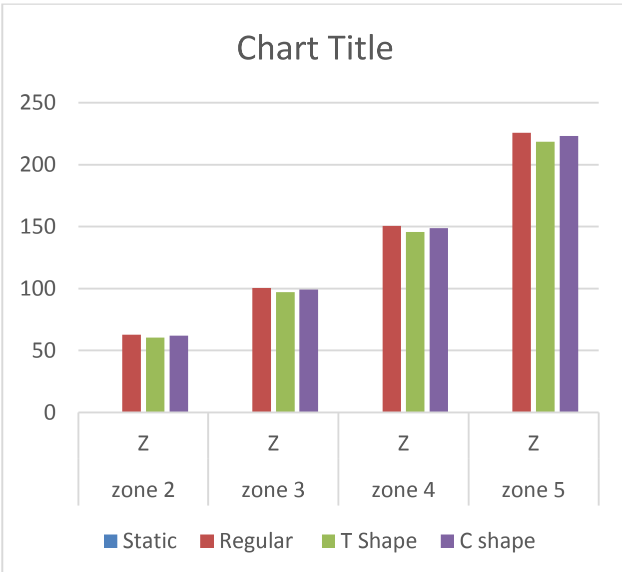

Fig 5.2: - Displacement in different zones along Z-direction by equivalent static method.

As per the above table and graph zone is ascending lateral displacement increasing and T shape irregular building has lesser displacement than regular shape and C shape in Z direction.

Table 5.3 Displacement in different zones along X-direction by Response spectrum method.

Building	**zone 2**	**zone 3**	**zone 4**	**zone 5**
Max displacement	**x**	**x**	**x**	**x**
RSM				
Regular	**29.617**	**40.689**	**59.409**	**89.112**
T Shape	**29.493**	**40.195**	**58.645**	**87.967**
C shape	**29.539**	**39.594**	**57.992**	**86.987**

Table 5.4 Displacement in different zones along Z-direction by Response spectrum method.

Building	**zone 2**	**zone 3**	**zone 4**	**zone 5**
Max displacement	**Z**	**Z**	**Z**	**Z**
RSM				
Regular	**36.957**	**50.773**	**73.726**	**110.587**
T Shape	**36.35**	**49.805**	**72.279**	**108.418**
C shape	**36.96**	**49.806**	**72.562**	**108.843**

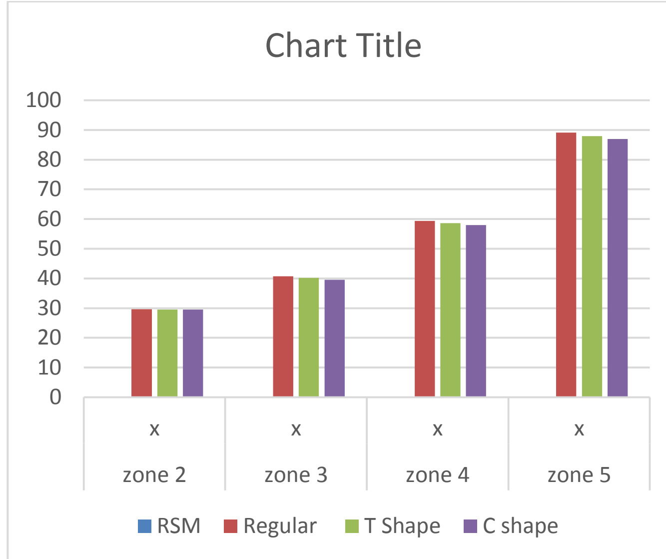

Fig 5.3: - Displacement in different zones along Z-direction throughout the height.

As per the above table and graph zone is ascending lateral displacement increasing and C shape irregular building has lesser displacement than regular shape and T shape in X direction.

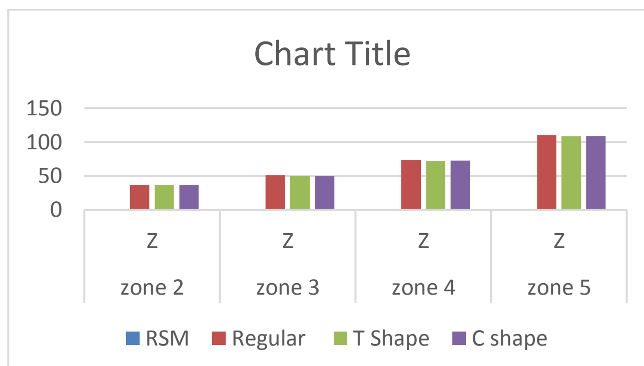

Fig 5.4: - Displacement in different zones along Z-direction throughout the height.

As per the above table and graph zone is ascending lateral displacement increasing and T shape irregular building has lesser displacement than regular shape and C shape in Z direction.

VI. CONCLUSION

Three different models are studied in this present research. Model 1 is a regular building model 2 is a T shape building and model 3 is a C shape building and all these models are made in all 4 zones i.e. zone 2 zone 3 zone 4 zone5. STADD-Pro software is used for analysis and the results obtained were satisfactory and following are the concluded remarks that can be established from the result.

1. Response spectrum method allows a clear understanding of the contributions of different modes of vibration. It is also useful for approximate evaluation of seismic reliability of structures.

2. Comparing the maximum base shear for both regular building and irregular building the maximum shear is obtained for regular building and T shape irregular building has lesser base shear than regular shape and C shape

3. Time period is maximum for C shaped plan configuration.

4. Average Frequency was maximum for T- shape Irregular Buildings.

5. Maximum displacement for regular shapes and minimum for irregular shapes. T shape irregular building has lesser displacement than regular shape and C shape in Z direction. C shape irregular building has lesser displacement than regular shape and T shape in X direction for static. But in dynamics T shape irregular building has lesser displacement than regular shape and C shape in both direction

6. Maximum lateral force for regular shapes and minimum for irregular.

7. T shape irregular building has lesser lateral force than regular shape and C shape.

8. In regular building the displacement, peak story shear, base shear, max shear force and bending moment are maximum than irregular models .and T- shape has minimum values than regular and C- shape models.

- **Future Scope**

1. Analysis can be done by using software STAAD Pro., SAP 2000 etc.

2. Analysis can be carried out using Pushover Analysis.

3. Different types of mass irregular and stiffness irregular building models considered for analysis.

4. Seismic analysis of irregular frames for different types of soil for different zones could be done.

5. Irregular buildings with different position of shear wall can be analysed results.

REFERENCES

[1] A Gauri G. Kakpure, Ashok R. Mundhada,"Comparative study of static and dynamic seismic analysis of multistoried rcc building by Etab: a review" International Journal of Emerging Research in Management &Technology Volume-5, Issue-12,Dec 2016, ISSN: 2278-9359

[2] S.Mahesh1, Mr. Dr.B.Panduranga Rao," Comparison of analysis and design of regular and irregular configuration of multi story building in IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 6 Ver. I (Nov- Dec. 2014), PP 45-52 various seismic zones and various types of soils using Etabs and Staad.",

[3] V. Rajendra Kumar , Ranga Rao.V," Comparative study on regular & irregular structures using equivalent static and response spectrum methods", International Journal of Civil Engineering and Technology (IJCIET) Volume 8, Issue 1, January 2017, pp. 615–622

[4] Ravi Kiran, Sridhar.R , "Comparative study of regular and vertically irregular building under seismic loading", IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308

[5] Rakesh Kumar Gupta1, Prof. D. L. Budhlani ," Review of is 1893:2016 with is 1893:2002 with plan irregularity", International Journal of Scientific Engineering and Research (IJSER),ISSN (Online): 2347-3878.

[6] Narayan Malviya, Sumit Pahwa ," Seismic analysis of high rise building with is code 1893-2002 and is code 1893-2016", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

[7] Raúl González Herrera1 and Consuelo Gómez Soberón," Influence of plan irregularity of buildings", The 14th World Conference on Earthquake Engineering October 12-17, 2008, Beijing, China

[8] T. Mahdi*a and V. Soltan Gharaieb," Plan irregular rc frames: comparison of pushover with nonlinear dynamic analysis", asian journal of civil engineering (building and housing) vol. 12, no. 6 (2011) pages 679-690.

[9] 1Amin Alavi, 2Prof. P.Srinivasa Rao,” Influence of torsional irregularities of rc buildings in high seismic zone” Australian Journal of Basic and Applied Sciences, 7(13) November 2013, Pages: 16-23.

[10] Rucha S. Banginwar, M. R. Vyawahare, P. O. Modani” Effect of plans configurations on the seismic behaviour of the structure by response spectrum method”, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 Vol. 2, Issue 3, May-Jun 2012, pp.1439-1443

[11] Narayan Malviya, Sumit Pahwa,” Seismic analys is of high rise building with is code 1893-2002 and is code 1893-2016 ”, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

[12] Miss.Aadishri D Kadam1, Dr. P.S.Pajgade,” DESIGNING OF SOFT STOREY FOR RC STRUCTURE USING IS-1893(PART I)-2016, AND IS-13920-2016”, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 05 | May-2018 p-ISSN: 2395-0072

[13] Ravikant Singh1 and Vinay Kumar Singh2 ,“Analysis of seismic loads acting on multistory building as per is: 1893-2002 and is: 1893-2016 :-A comparative study”, Journal of Civil Engineering and Environmental Technology p-ISSN: 2349-8404; e-ISSN:2349-879X; Volume 4, Issue 5; July – September,2017, pp. 405-408

[14] Akhil R, Aswathy S Kumar,“Seismic analysis of regular and irregular buildings with vertical irregularity using Staad.pro” International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Volume: 04 Issue: 06 | June -2017 www.irjet.net p-ISSN: 2395-0072

[15] Arun Babu M, Ajisha R,”Analysis of multistoried building in different seismic zones with different soil conditions”, International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 05 | May-2018 www.irjet.net p-ISSN: 2395-0072.